

Civil society engaged in wildfires: Mediterranean forest fire volunteer groupings

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ABSTRACT

In fire-prone areas such the Mediterranean basin, wildfire risk means a societal challenge. Governments in modern welfare states have generally addressed it through a “zero fire policy”, focusing on suppression and professionalization. Such approach provides security to local populations, who in turn may detach from the socio-ecologic phenomenon of wildfire and become passive actors. In the face of increasingly virulent wildfires, local communities are often not prepared with consequent damages and casualties.

Yet, some regions show pro-active locals organizing their efforts to tackle wildfires. These fire volunteer groups suppose a social innovation in rural communities that help in their adaptation to climate change. Going beyond homeowners' preparedness, the actions of volunteers range from supporting firefighters' efforts, first attack and/or year-round prevention. The investigation of these communities is in its infancy despite its practitioner and policy interest.

In this study, we shed light on this civil society engagement across different Mediterranean forest settings, namely from predominantly public forest ownership in Greece, to predominantly private in Catalonia (Spain) and virtually entirely private in Portugal. Collecting data through a survey, the type of activities of these volunteer groups, their relations with fire and local actors (i.e. social capital) and trajectory have been analysed to find possible trends.

Statistical results show that their portfolio of activities relates to their group size (i.e. available human resources) and their structural and relational social capital. Preliminary insights show an improvement in trust with fire and forest actors owing to the fire volunteer group establishment. No evidence has been found of forest area covered by fire volunteers, recent fire experience or variety in members' profile to affect the type of activities. The results are discussed in the frame of social capital theory and suggestions for further research are put forward.

1. Introduction

1.1. Wildfires and citizen engagement

Wildfires are a recurrent phenomenon in Mediterranean climate areas, while they are becoming increasingly prevalent elsewhere. Despite being part of the ecosystem, large wildfires can provoke severe losses primarily in human assets (e.g. houses, infrastructure, investments – crops, stockbreeding, forestry), and ecological features (e.g. soil erosion, biodiversity loss) (Pausas et al., 2008). While rural societies have been using fire for their traditional farming activities, current urban-dominated societies contemplate fire as an enemy to fight against. The loss of some agricultural knowhow and inopportune fires must be also acknowledged as one of the causes of human-related

wildfires. Fire extinction services have been set up in the different countries, considered as a part of the welfare state. Their target is generally the suppression of every small wildfire, as they see them as potentially a large one. Prescribed burning is still a rare practice. In parallel, the urban sprawl towards nature areas implies an increasing buffer area of interaction between (often unaware) homeowners -and hence human lives and their assets- with potential flammable woodlands – the so-called Wildland-Urban Interface (WUI). Moreover, climate change scenarios and evidence in Mediterranean Europe show a shift from small, controllable fires, to megafires out of the extinction capacities. For these reasons, the paradigm is progressively changing – at least at the technical level – towards “living with wildfires” (Biro, 2009; Moritz et al., 2014).

Such a new viewpoint implies addressing the wildfire phenomenon

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by coupling human and forest dynamics within a socio-ecological system. For an effective landscape-scale adaptation strategy, different levels of human decision-making apply. McCaffrey (2004) puts forward that both individual and communal changes are needed for fire mitigation. Yet, Jakes et al. (2007) consider that individual actions have a limited effect, and propose a model of community preparedness where collective and organisational (chiefly government) decisions act in synergy to influence the activities around the wildfire emergency management: its prevention, readiness, response and recovery phases. These “communities”, however, are made up of different types of actors (e.g. private landowners, visitors, WUI homeowners, rural inhabitants), with heterogeneous motivations. Given the public nature of wildfire prevention and protection (Gan et al., 2015), community preparedness requires incentives for coordinating collective decisions to achieve community actions and overcome potential free-riding. Economic reward reflects a limited incentive in Mediterranean forests, as they generally show low profitability according to the traditional markets (Solano et al., 2007), which is the reason why many landowners do not invest in forest tending. Hence, other community treats such as local networks, landscape identity or human safety become more likely motivations for changing behaviors in fire-prone communities. By channelling locals' capacities to reduce wildfire risk, defeatism is counteracted and empowers local citizens through the sense that something can be done to address the issue within their own possibilities (Jakes et al., 2007).

Fostering private citizen responsibility for wildfire management has led to a renewed focus on methods for engaging populations in collaborative processes that define wildfire risk, prioritizing strategies to reduce fire impacts and implementing adaptive actions that re-incorporate fire as an ecosystem process (Carroll and Paveglio, 2016). Human adaptation to wildfire includes the local ability to organise in response to disturbance (Smith et al., 2016). From spontaneous citizens' actions triggered in case of wildfire, tragedy-driven coordination has evolved in some areas in different types of volunteer initiatives. In the following we refer to “fire volunteers” as the more or less formalised civic, non-professional initiatives that regularly conduct coordinated actions contributing to the wildfire emergence management (e.g. minimising their occurrence, vulnerability, and/or impacts), which redound to the benefit of fire-prone communities.

Previous scholars have analysed some typologies of these organisations –volunteer firefighters in Australia (McLennan and Birch, 2005) or WUI Fire Safe Councils in the USA (Everett and Fuller, 2011)–, especially in Anglo-Saxon countries (Hesseln, 2018; McCaffrey, 2015). These countries show a large experience in community self-organization and third sector initiatives. Yet, there is a gap of knowledge of such organisations in the Mediterranean context, often showing less tradition of self-organization and stronger state role.

In addition, very few studies have investigated the social aspects of wildfire management (prevention, suppression, restoration) in the Mediterranean region. The aim of this explorative work is to shed light on the fire volunteer organisations, as a potential cooperative tool for increasing Mediterranean community resilience –or at least, reduce their wildfire vulnerability (Prior and Eriksen, 2013). For the purpose of this paper, we dismiss non-regular initiatives (e.g. punctual volunteers of summer work camps) and discard the volunteer firefighters and civil protection, given their activity centred around fire suppression and their conceptualisation mirroring professional firefighters or emergency services respectively. Our focus is then on voluntary bodies specialised in wildfires targeting the community preparedness –and possibly other fire emergency phases, as preparedness is the key social response to build community resilience (Prior and Eriksen, 2013). Yet, for an adequate contextualisation of the analysed fire volunteers' activities, the available information regarding other existing volunteer initiatives is also presented. Indeed, in some places, these volunteer groups may have evolved to assimilate with civil protection or volunteer firefighter bodies; in those cases, our findings could also be applicable for them.

We adopt a Social Capital (SC) theory analytical approach, given that networks in rural areas, norms and trust can play a vital role in the formation and activity of volunteer groups (Everett and Fuller, 2011; Fischer and Jasny, 2017; Pretty, 2003). Moreover, we postulate that these initiatives constitute social innovations insofar as they are still scarce (i.e. novel) in the Mediterranean and imply the reconfiguration of social practices through the engagement of civil society actors in response to the societal challenge that a wildfire signifies, which seeks to enhance societal well-being (Polman et al., 2017).

1.2. Theoretical background: Social capital and wildfire volunteers

Checking the scientific databases, it can be observed the incipency of social science research on wildfires in the Mediterranean countries. Looking at governance features to achieve resilient Mediterranean communities, a few scholars have analysed aspects of the socio-ecological relations. Canadas et al. (2016) and Valente et al. (2013) discuss how collective management, fuelled by government programmes, affect communities' ability to tackle wildfire risk in Portugal. González-Hidalgo et al. (2014) illustrate how political discourses can impact fire management and community resilience in Catalonia. Greiving et al. (2012) suggest that fire governance would benefit from changing top-down approaches to a more collaborative management of disasters through illustrative forest fires in Lazio (Italy) and East Attica (Greece). A few other articles analyse community-based engagement in various Mediterranean countries, such as in Spain (Vélez Muñoz, 2007) and in Turkey (Kurtulmuslu and Yazici, 2000). However, no study has analysed wildfire volunteer groups at the Pan-Mediterranean level, which will be our focus. Instead, studies on voluntary citizens' involvement in wildfire management have focused on Australia (Fairbrother et al., 2013; Frandsen et al., 2011; Macdougall et al., 2014; McGee, 2011), the USA (Agrawal and Monroe, 2006; Everett and Fuller, 2011; Jakes et al., 2007; Smith et al., 2016) and New Zealand (Jakes and Langer, 2012).

Among the community characteristics that facilitate adaptation to wildfires (McCaffrey et al., 2012), previous scholars (Agrawal and Monroe, 2006; Bihari and Ryan, 2012) found that individuals with higher levels of SC engage more in fire preparedness. Putnam (2000) referred to Social Capital as “...connections among individuals – social networks and the norms of reciprocity and trustworthiness that arise from them”. While Putnam emphasizes such connections as important for the productive activity of the group, Coleman acknowledges the benefits of the group relationships and linkages for the individual to thrive (Andriani and Christoforou, 2016). Regarding natural resource management, SC refers to the social norms and bonds as key for sustainable livelihoods (Pretty and Ward, 2001). It is important to coordinate the management of common resources in order to avoid free-riding problems. Yet, in wildfire management the focus is not on a common good but on a public bad (Ostrom and Ostrom, 1977). Therefore, social norms and shared values embedded within SC become important when coordinating efforts to avoid inaction and rather align individuals into a collective action tackling wildfires.

Social Capital can be analysed from different angles: from the connectedness viewpoint, it is referred as the structural SC, whereas when the focus is on social norms and trust, the analytical dimension is the relational SC (Nahapiet and Ghoshal, 1998). The typology of structural relations differs from bonding and bridging (Granovetter, 1973): bonding linkages occur between members of similar characteristics (e.g. family ties, members within a volunteer group), while bridging links take place between people of different groups (e.g. among volunteers of different municipalities). Bonding links facilitate sharing resources and views, and ultimately “collective decisions” –in Jakes et al. (2007) framework terms–, whereas bridging linkages facilitate exposure to new ideas and hence to innovative approaches. Both aspects, then, can have an influence in the range of wildfire risk management activities the volunteers conduct –i.e. community actions (Bodin and Crona, 2009; Jakes et al., 2007). For example, a group may

be only focused on fire suppression due to a limitation to learn from innovative approaches, or rather lack united efforts to engage in other actions.

On the other hand, trust is defined as the expectation that somebody will act as what another individual or group perceives as correct, or will follow the norms that have been set by the group (Uslaner, 2001). Trust is important to manage resource more efficiently and effectively (Davenport et al., 2007). Distrust in natural resource management often leads to conflict in the field. According to Davenport et al. (2007), the role that trust plays between local communities and agencies in natural resource management should receive more attention in the academic literature. In forest fire situations, trust affects numerous aspects of fire risk management (Toman et al., 2006). High levels of trust between community members creates social obligations (Pretty and Ward, 2001:211) and could then prevent negative behaviors regarding natural resources management (e.g. arsonists) through informal control (Bodin and Crona, 2009). Trust can also enhance the relationship and communication between firefighters and locals regarding fire suppression scenarios.

Based on these SC aspects, the research questions that guide our work are:

1. How did these groups emerge or consolidate?
2. How do these groups coordinate/interact with other wildfire related actors?
3. Do the variety of activities fire volunteer groups conduct relate to the group's SC?
4. Does the group SC affect local arsons?

For the purpose of this work, we explore the connectedness (i.e. structural SC) and the group's trust (i.e. relational SC) as factors put forward by previous scholars as relevant. The Social Capital theory postulates that having different profiles within a network provides new insights, meaning that members bridging other divides facilitate the introduction of innovations (Andriani and Christoforou, 2016). We then hypothesise that the more heterogeneous a group is, the more likely it the group to conduct a wider range of activities. For example, volunteer groups constituted mainly by farmers or forest owners could have certain priorities, while other profiles (e.g. WUI homeowners) could have a different focus. In terms of capacity, we also conjecture that the larger the group is (i.e. number of members), the easier it is to conduct more actions. Our hypothesis for the third question is that wildfire volunteer groups with stronger structural SC carry out more activities than those with a weak SC. As potential confounding factors, we control for the covered forest size (i.e. larger asset to protect), the recent fires (i.e. local awareness), the recurrence of their interactions and the antiquity of the group, which could affect the array of activities. Regarding the fourth question, we employ the “perception of arsons” as a self-reported proxy owing to the lack of disaggregated data at the local level for the “arson” variable. Here we test whether volunteer wildfire groups with stronger trust levels, indirectly affect the local social norms and hence reduce incentives for arsons.

2. Material and methods

This study consisted in two stages: firstly, identifying wildfire-related volunteer initiatives in Mediterranean countries –based on literature interview and a broad-and-shallow expert consultation (Section 2.1), and secondly, answering our research questions via to the groups (Sections 2.2. and 2.3).

2.1. Prospecting Mediterranean wildfire volunteer groups setting the case study area

Scouting potential fire volunteer initiatives across the Mediterranean implied an extensive international literature review,

complemented with a short survey (four questions) sent to experts for confirming and/or enriching the literature (lack of) findings. The scholarly search was carried out using SCOPUS and Google Scholar, including both scientific and technical documents. The literature review looked at all countries in the Mediterranean.¹ Besides, 46 experts in the field of forest management, civil protection, natural resources and forest fire management were contacted from across those countries, from which 18 provided information about their country (lack of) initiatives.

This review revealed five countries with some type of fire volunteers: Portugal, Greece, southern France, a few regions in Spain (i.e. Catalonia, Valencia, Andalusia), and Italy (i.e. Sardinia). This is not surprising given that most articles, when discussing forest fires, refer to these as the five most fire prone countries -i.e. so-called “fire club” (Vélez Muñoz, 2007). These countries alone have a total burnt area of about 450,000 ha/year, with an annual cost of 1.5 billion euros in damages (Verkerk et al., 2018). Yet, the analytical part of this article will be restricted to Spain, Portugal and Greece. These countries show a similar rate of forested area (between 30% in Greece to 37% in Spain) but vary in terms of land ownership, with Portuguese forests having a very high rate of private ownership (97%) when compared to Greece (22%), where public forests dominate. Spain falls in between these two countries, depending on the region considered. These ecological and administrative characteristics (i.e. forest relevance, and liability for wildfire and its damages, respectively) influence wildfire management governance, which offer insights for other countries.

2.2. In-depth data collection

To respond to our research questions, we systematically collected structured data regarding the Catalan Forest Defence Groups (ADF) in Spain, the Forest Intervention Zones (ZIF) in Portugal, and the local volunteer groups of Greece, through a survey. The survey design included a section on the volunteer group characteristics and their interaction with other stakeholders (frequency of interrelations and trust aspects). Table 1 gathers the common questions and their corresponding variables (complete questionnaire in Supplementary material 1). Each survey was translated into the local language of the study areas, and slightly adapted to reflect regional differences. To gain expert insight from persons who are actively involved in their respective regions and enrich the literature and survey information regarding those initiatives, in-depth experts interviews were conducted, two from Greece and one from Portugal, complemented by a field visit to two Catalan volunteers.

In Greece, contacts were gathered through the WWF Greece, who have been working closely with community groups engaged in fire management around the country. In total, 42 surveys were sent out to groups from all around Greece, including some small island groups; 11 responses were received. In Catalonia, the *Secretariat de les Federacions d'Agrupacions de Defensa Forestal* (SFADF) channelled the survey through to 40 of their members, with 31 responses received. The unit of analysis is the fire volunteer group, except for the Portuguese ZIFs, given the lack of contacts at the single ZIF level. ZIFs are managed by forestry or agricultural associations, who often control more than one ZIF. In total, 36 of these associations were contacted, based on the information available through the website of the *Instituto da Conservacao da Natureza e das Florestas* (ICNF). They were requested to reply on behalf of all the ZIFs they handle, and in case of significant differences across them regarding these questions, we required differentiated questionnaires for each. Four associations responded, representing 16 ZIFs. In order to be accurate with the level of reply obtained, the

¹ Vatican City, San Marino, Monaco, Gibraltar, Malta, Egypt and Libya were excluded since their forest areas are very small, as well as Syria owing to the current difficulties of gathering data from there.

Table 1

Questions, related variables and label. Questions with Likert-scale answers: * Very often, Often, Sometimes, Seldom, Never; ** Strongly agree to Strongly disagree.

Label	Variable definition	Question
#members	Number of members in the group. Structural SC – size.	<i>How many members does your organization have?</i>
memb_profile	Measure of the diversity of the groups based on profession. Structural SC – bonding.	<i>Which of the following profiles are participating members of your organization? (check all that apply): Local officials / Firemen / Forest owners / Forest wardens / Farmers / Mayor / Other volunteers / None of the above</i>
year_est	Antiquity, the year the group was established. Operational capacity.	<i>In what year was your organization established?</i>
area_ha	Covered forest area in hectares	<i>How large is the forest area your organization covers?</i>
activ_cond	Variety of activities: number of different activities conducted. Operational capacity.	<i>Select from the list the measures that your organization takes.</i>
interact_FF	The number of interactions with professional firefighters. Structural SC – bridging.	<i>* How often does your organization interact with the firefighters?</i>
interact_lo	Frequency of interactions with local officials. Structural SC – bonding.	<i>* How often does your organization interact with the Local officials?</i>
interact_ForG	Frequency of interactions with the forest wardens. Structural SC – bridging.	<i>* How often does your organization interact with the forest wardens?</i>
Comm_olvg	Communication with other local volunteer groups (excludes other fire groups) Structural SC – bonding.	<i>* How often does your organization communicate with other local volunteer groups?</i>
coll_ovfg	Collaboration with other volunteer fire groups. Structural SC – bonding.	<i>* How often does your organization collaborate on projects with other fire volunteer groups?</i>
coll_olvg	Collaboration with other local volunteer groups (excluding other fire groups). Structural SC – bridging.	<i>* How often does your organization collaborate with other local organisations?</i>
fire_5year	Number of fires responded to in the last 5 years	<i>Do your members pay a membership contribution?</i>
memb_fee	Membership fees. Operational capacity.	<i>Besides possible members' contributions, how does your organization finance activities? (check all that apply)</i>
Fund_source	What is their main source of funding and how often do they receive funding from that source? Operational capacity.	<i>** The fire volunteers reduce the possible arsons produced by locals due to informal control in the town.</i>
Reduce_arson	Group's perception of whether the group reduces the possible arsons due to informal control	<i>** Local inhabitants trust the fire volunteers.</i>
Trust_localtoFV	Trust from the local inhabitants to the fire volunteers. Relational SC- trust.	<i>** Local fire volunteers trust the locals.</i>
Trust_Fvtolocal	Measure of trust from the fire volunteers to the locals. Relational SC- trust.	<i>** Firefighters trust the fire volunteers.</i>
Trust_ProFFtoFV	Measure of trust from the professional fire fighters to the fire volunteers. Relational SC- trust.	<i>** Before the fire volunteer group was established, relations with the firefighters was poor.</i>
Relat_before	Measure to assess the relationship before the groups establishment. Relational SC- trust.	<i>** After the fire volunteer group was established, relations with local firefighters improved</i>
Relat_after	Changes in relationship after the groups establishment. Relational SC- trust.	

analyses were done assuming the aggregation of those ZIFs at the association level.

2.3. Data processing and analysis

All questionnaires were checked for consistency and a final number of 46 observations (11 Greece, 4 Portugal, and 31 Catalonia) was used for the statistical analysis. A limitation of our study falls precisely in the small amount of observations for Greece and Portugal, hence the findings are to be interpreted carefully. Nonetheless, they also reflect preliminary findings for this exploratory study. Two additional variables were built to aggregate altogether the different aspects of SC and trust captured in the questionnaires. Specifically, two independent Principal Component Analyses (PCA) were run to disclose whether these questions could work synergistically and could be aggregated.

The structural SC PCA included six correlated variables related to volunteers' group collaboration, communication and interaction, measured both at internal and external level. These variables include three measurements of bridging SC (*interact_FF*, *interact_ForG* and *coll_olvg*), and three measurements of bonding SC (*interact_lo*, *Comm_olvg*, and *coll_ovfg*). Similarly, the relational SC included five measurements of trust: between the fire volunteers and the local inhabitants (*Trust_localtoFV* and *Trust_Fvtolocal*), between the fire volunteers and the professional fire fighters (*Trust_ProFFtoFV*), as well as two measurements to assess the relationship strength before and after the groups' establishment (*Relat_before* and *Relat_after*).

Both PCAs did not show clear clusters among observations (Supplementary material 2). Nonetheless, in both cases the first PCA component behaves as a linear transformation being negatively

correlated with all variables (Eq. (1) and Eq. (2)).

$$StrSC_i = -0.40interact_FF - 0.28interact_lo - 0.35interact_ForG - 0.48Comm_olvg - 0.51coll_ovfg - 0.39coll_olvg \quad (1)$$

$$RelSC_i = -0.31Relat_before - 0.50Relat_after - 0.45Trust_ProFFtoFV - 0.47Trust_Fvtolocal - 0.49Trust_localtoFV \quad (2)$$

Given its large explanatory power in both PCAs (Respectively 0.54 and 0.41 of the overall variance), we deemed appropriate to use their derived coefficients to build a linear combination of structural and relational SC variables. Such linear combination assumes that each SC dimension is independent, permits a relative simplicity for interpretation (linear model), and facilitates the disclosure of the single variables' effect for policy recommendations.

The results of these aggregations along with additional explanatory variables were used to build two regression models. These aim to disentangle, respectively, (i) the drivers of the volunteer groups concerning the number of conducted activities (e.g. the group operational capacity) and (ii) the drivers behind the group's perception of whether their activities effectively reduce the existing perceived arson level. Only those explanatory variables with higher response rates were included in the models – e.g. reason for discarding the variable on recent fires. On the contrary, variables showing partial and missing answers were tested for relationship with response variables via correlation analyses.

For the first model, a multiple linear regression was fitted to the data taking as predictor variables both structural and relational SC proxies, and additional operational capacity factors (i.e. number of members and members' heterogeneity). The model includes a country

fixed effect ($country_i$) in order to control for the time invariant characteristic of the volunteers' different areas of origin (Eq. (3)).

$$Activ. variety_i = \beta_0 + \beta_1 \cdot RelSC_i + \beta_2 \cdot StrSC_i + \beta_3 \cdot Members_i + \beta_4 \cdot memb_profile_i + country_i + \varepsilon_i \quad (3)$$

The second model was implemented as an ordered logit regression, owing to the ordered nature of the category arson variable (Eq. (4)). Its explanatory variables were the same as the former model.

$$Arson perception_i = \beta_0 + \beta_1 \cdot RelSC_i + \beta_2 \cdot StrSC_i + \beta_3 \cdot Members_i + \beta_4 \cdot memb_profile_i + country_i + \varepsilon_i \quad (4)$$

To find the most parsimonious model, backward stepwise analyses based on the Akaike Information Criterion (AIC) were used. Additional tests were run to check existing collinearity among variables and individual model specific assumptions. Statistical analyses were performed with the programming software R (R Core Team, 2017; RStudio Team, 2017). Correlation analyses were run using the Pearson's product moment correlation coefficient.

3. Results

This section starts by describing the findings obtained from the literature review and expert consultation for Mediterranean countries, first as a general overview (Section 3.1.1.), followed by the specifics for three case studies (Section 3.1.2. – Catalonia (Spain), Section 3.1.3. – Portugal, and Section 3.1.4. – Greece). Next, the results of the statistical analyses are presented, describing the interaction of these groups with other wildfire agents (Section 3.2), on the effects of SC and other variables in the variety of activities conducted (Section 3.3.); and the effects of SC on their perception on arsons (Section 3.4).

3.1. The portfolio of fire volunteers across the Mediterranean

3.1.1. Overview of Mediterranean wildfire volunteers

Table 2 shows the preliminary mapping of existing initiatives. The literature reveals several initiatives in Anglo-Saxon countries (United States, Australia and New Zealand), namely volunteer firefighters, municipality-level programs for WUI homeowners, and fire emergency planning. The technical literature and initial expert surveys reveals some type of fire-related voluntary initiative in five Mediterranean countries, all of them in the northern rim (Europe). In some regions these initiatives are part of a civil protection body (i.e. dealing with any type of emergencies, not only wildfires), in others behave as firefighters-like (i.e. only focused on direct fire suppression), and in others behave as a mixture supporting wildfire prevention, preparedness or suppression actions alike. The prevention activities identified consist of patrolling and campaigns against negligent fires. As fire preparedness actions conducted by volunteers, fuel treatments and WUI self-safety measures stand out as the most frequently mentioned. Building and maintenance of wildfire suppression-related infrastructure, as well as wildfire planning also constitute some volunteer activities. Response activities cover from direct intervention (e.g. first attack) with more or less autonomy with respect to professional firefighters, assistance to firefighters in the rear-guard, and evacuation. The least varied group of fire volunteer activities refer to the post-fire recovery stage, where some civic or environmental NGOs conduct punctual reforestation campaigns.

3.1.2. Catalonia (Spain)

While Catalonia has a history of volunteer efforts to suppress and prevent wildfires since the 1960's, forest fire legislation was officially established in 1986 by the Agriculture Department through the *Foc Verd* program; elaborated in 1999 (Peix et al., 1993). In parallel with the veterinary prevention groups, the Forest Defence Groups (*Agrupacions*

Table 2
Typologies of civil society engagement in tackling wildfire risk management as identified in Mediterranean climate areas. Source: own elaboration based on experts' information and literature review. Acronyms: WUI: Wildland Urban Interface; ZIF: Portuguese Forest Intervention Zones; VLC: Valencian civil volunteers (Spain); ADF: Catalan Forest Defence Groups (Spain); ASA DFCL: Aquitaine Forest Fire Defence Associations (France); ACIF: Valencian Associations Against Wildfires; AUS: Australia; USA: United States of America; NZ: New Zealand; CAT: Catalonia; PT: Portugal; FR: France; GR: Greece.

Emergency phase	PREVENTION (to avoid wildfires)	PREPAREDNESS (to minimise vulnerability)	RESPONSE (to minimise extent)	RECOVERY (to regain pre-fire conditions)
Activities: groups or countries [non-volunteer related tools]	Patrolling: VLC, ADF Campaigns: VLC, ADF	Silvicultural treatments: ZIF, ADF WUI self-safety: USA Fire-Adapted Communities, Fire Safe Councils, Firewise Communities; AUS Bushfire Ready Groups	Early detection: VLC, ADF Direct suppression (close-to-professional): Volunteer firefighters in CAT, PT, FR, AUS, USA, NZ Direct suppression supporting firefighters: ADF, ACIF, GR Rear-guard support to firemen: VLC, Civil Protection Evacuation: Civil Protection	Reforestation: several NGOs

de Defensa Forestals - ADF) were also established in Catalonia. Their regulation states that ADFs are non-for-profit associations devoted to forest protection within the boundaries of one or more municipalities. Their constitution mandatorily involves the town council and a share of private forest owners, but they also envisage the inclusion of other interested local actors. ADFs' collective mission is the prevention, mitigation and suppression of forest fires with a list of various objectives (SFADF, 2016):

- Support the preparation and implementation of municipal surveillance and forest fire preparedness programs.
- Actively participate in the organization, control and implementation of forest fire fighting and mitigation measures (e.g. creation and maintenance of infrastructure, road networks, firebreaks and water points).
- Carry out dissemination campaigns for forestland owners regarding preparedness and forest fire fighting actions.
- Prepare awareness activities for rural and urban population in their area.
- Support forest fire fighting actions through first response, or mop up after the incident.

In total, there are 305 ADFs in 675 municipalities across the region (SFADF, 2016), gathering between 6000 and 7000 volunteers, however, it is estimated that only about 200 of them are active. Some ADFs often federate at the supra-municipal level. Complementarily, Catalonia also counts with 111 Civil Protection organisations -registering 1354 volunteers, and 2171 volunteer fire fighters -these figures reveal the relevance of the ADFs in comparison to other local volunteer initiatives. Besides professional firemen, only the ADF members with yellow card and volunteer firemen can act in the fire itself. The rest of volunteers Civil Protection and ADF with green card can support the extinction through logistics. At the regional level, 136 ADFs join in the Secretariat of Federations of ADFs (SFADF).

Given that 1986 was one of the worst fire seasons in recent history, the government decided to respond, i.e. with the decree regulating the ADFs. Fig. 1 shows that over one third of the current ADFs were established one year after 1986. The data also shows the trend that the subsequent years of peak fires are followed by an increase in the establishment of new fire volunteer associations, taking into account that from 2004 onwards near the totality of the forested municipalities under Mediterranean climate were covered by some ADFs.

As is the nature of these groups, fire preparedness makes up a high percentage of their portfolio of activities (38%), while the rest is

accounted for through fire suppression activities (30%) and awareness campaigns (26%) respectively. Most of their funding (Fig. 5) comes from public sources (86%), with 35% from the municipalities and 38% from the Catalan Government. ADFs located in the Barcelona province usually receive also funds from the provincial council.

3.1.3. Portugal

In the aftermath of the 2003 fires, the Portuguese government decided to invest heavily on research around all aspects of forest management (environmental, social, economic and political) in order to prevent forest fires (Oliveira, 2005). One of the concerns raised was the need for a landscape-scale land management to prevent catastrophic wildfires, which required the coordination of the highly fragmented landowners. The efforts by the government accumulated into the establishment of *Zonas de Intervenção Florestal* (ZIF). In order to manage these small land packages properly, the government decided to implement ZIFs in 2005 (decree-law 127/2005). Fig. 2 shows that even if the regulation of the ZIFs was issued in 2005, they were formalised only from 2006 onwards (after a second catastrophic season). In 2009 there was a reform (decree-law 15/2009) in order to increase their scope, which also triggered the constitution of many new ZIFs.

A ZIF is a continuous, bounded area of primarily forest land, which can include all types of land ownership, including common land (Valente et al., 2013). In order to establish a ZIF in a private area, three criteria are required: (i) the area must be minimum 750 ha; (ii) it must include a minimum of 50% of forest owners or producers in the area; and (iii) a minimum of 100 different properties must be involved. ZIFs have three overall objects, as follows: to promote sustainable forest management; to mitigate current constraints to forest intervention due to land structure and size; and to develop structural measures for protection against forest fires (Valente et al., 2013). ZIFs gather private forest owners for fire mitigation through joint management.

The reasoning why ZIFs were implemented is that all of these small NIPF areas are difficult to manage at an effective territorial level: because landscape fire risk mitigation follows a non-linear production function, spatial coordination in fuel treatments across landowners is required to reach a threshold that renders a minimum efficacy (Canadas et al., 2016). In 2012, there were 161 ZIFs that covered an area over 800,000 ha with 20,000 members (Canadas et al., 2016).

Fire preparedness makes up a large portion of their activities (47%), with fire suppression (26%) and awareness (24%) combined to make up half of the ZIFs portfolio. Very few other activities take place (3%). Public funding contributes to 85% of the funding received (Fig. 5), with national and provincial funding each contributing (31%) and EU

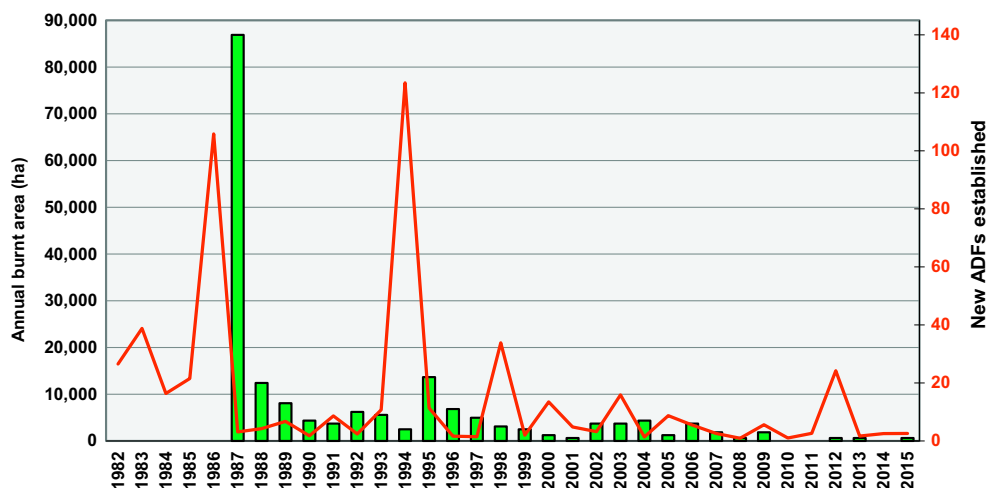


Fig. 1. Evolution of the establishment of fire volunteer groups in Catalonia according to available information (i.e. 299 ADFs) and annual burnt area. Sources: SNADF, several ADF websites, Bombers (2017).

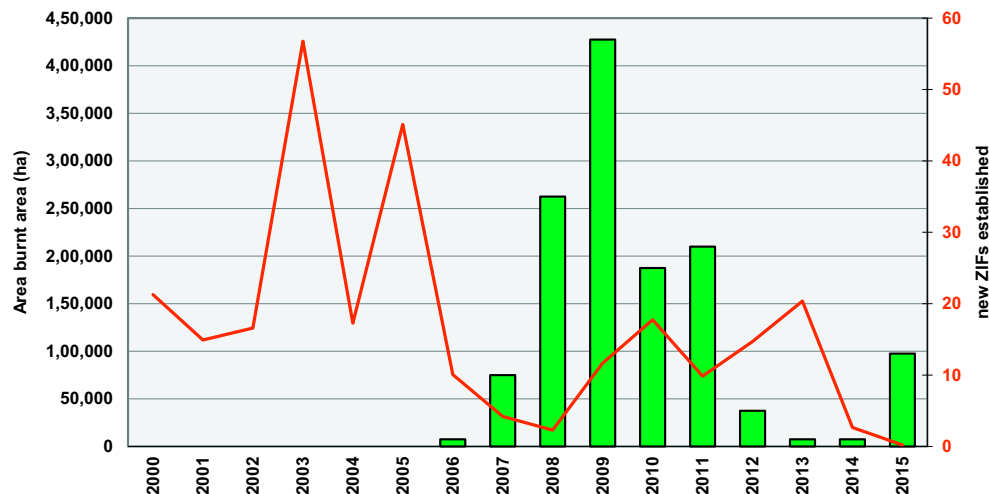


Fig. 2. Evolution of the establishment of ZIFs in Portugal according to available information and annual burnt area. Source: (EFFIS, 2017; ICNF I.P., 2017).

funding at 23%. No funding is obtained from the provincial government. The remaining 15% is split evenly between private donations and fundraising events. These two programs are publically funded through the *Fundo Florestal Permanente* (FFP) (ICNF, 2017). The funding allocated to the ZIFs from the FFP is used to support only the constitution of the ZIFs, but not the implementation measures. According to an expert (Valente, pers. Comm.), this funding covers 75% of all ZIF costs, meaning that the locals need to gather the extra 25% in order to carry out ZIF tasks and measures. Therefore, in order to maintain the ZIFs, a common fund supported by the members is required (Valente, Pers. Comm.).

There are also volunteer fire fighters, known as the *bombeiros voluntarios*. They are employed during the season and are paid humble hourly rates (Collins, 2007). These volunteers dominate in the Portuguese forest fire system: in 2009 there were 4255 volunteer firefighters versus 600 professional staff of permanent brigades (Beighley and Hyde, 2009). Collins (2007) also highlights that these volunteers require an improved training and an effective coordination. These groups very often are composed by forest owners (especially in the north and central regions of Portugal). While these groups are relevant, we have rather focused our attention in the ZIFs as a volunteer tool very specific for Portugal, which tackle not only fire suppression but also preparedness.

3.1.4. Greece

Volunteer groups in Greece have been present since the 1980s. However, since 1998, there has been a large growth in the number of these groups due to a catastrophic forest fire. The number of these groups was then amplified again after the 2007 wildfires.

When people form a fire volunteer group in Greece, they must register with the General Secretariat of Civil Protection (GSCP). According the interviewees, there are 400 groups registered with the GSCP, but only about 30% (120) of them are active. There are two methods to register in Greece with the GSCP, either the group signs up as a Volunteer Organization or an individual can register as an Expert Volunteer (GSCP, 2017). The Volunteer Organisations are NGOs and other volunteer organisations that are willing to participate in civil protection, while an Expert Volunteer is skilled in any aspect of civil protection, not only fire management (GSCP, 2017).

Fig. 3 also shows a time lag of one or two years between catastrophic seasons and the creation of fire volunteer groups. Yet, this graph has been built on the limited information available from the sample.

According to expert interviews, no groups in Greece are involved in fire preparedness. Volunteer fire groups are only involved in

suppression of forest and/or structural fires. According to our informants, this could be due to the mentality of these groups, and the lack of awareness about the advantages of prevention from the authorities. The status and the high consideration that the fire fighters have in the local communities incentivise many people to become involved in firefighting. Local experts' interviews suggest that this can also partly explain the lack of emphasis on pre-fire mitigation actions, because such activities are “invisible” to the community and hence do not entail social recognition. Contradicting this, seven respondent groups report conducting different preparedness measures (18% of the total actions), however fire suppression makes up 45% of their portfolio of activities. This shows that either the group managers want to show more undertakings, or they count with a deeper first-hand knowledge of their activities.

The interviews reveal that FAO and the Laisas Foundation covered funding for volunteer organisations from 2007 to 2010. Laisas contracted the WWF Greece to assess the volunteer groups' performance trying to homogenize their actions, select the donations based on their requirements (predominantly, essential equipment), and providing training. However, in 2010, this funding stopped. Currently most of the funding (Fig. 5) either comes from the municipalities (30%), private donations (35%) and fundraising events (27%), which in total sums up to be 92%. The remaining 8.3% is split between provincial funding (7%) and national funding (2%). No funding is obtained from the EU.

3.2. Relations with other fire-related actors

Responding to our second research question, Fig. 4 illustrates that overall Catalonia has a stronger network, given the upward skew of the data. Portugal shows the weakest structural SC, however, more respondents would be needed in order to justify this statement. Of the six separate questions, the one that scored the lowest in all three cases was the interactions with the forest wardens (Mean: Greece = 1.82; Catalonia = 2.45; Portugal = 2).

While the Greek volunteers' interaction with professional fire-fighters occurs, experts find that communication with other firefighting stakeholders is one of the main problems of the Greek system. Experts report no standard operational procedure regarding fire suppression in Greece. All the actors have their own way of carrying out tasks that sometimes conflict with one another. This especially comes into play when analysing the relationship between the local fire commander and the volunteers. As stated by our interviewees, whether the locals have a good relationship with the local fire commander often determines if the volunteers are called upon, which can create social tension in the community.

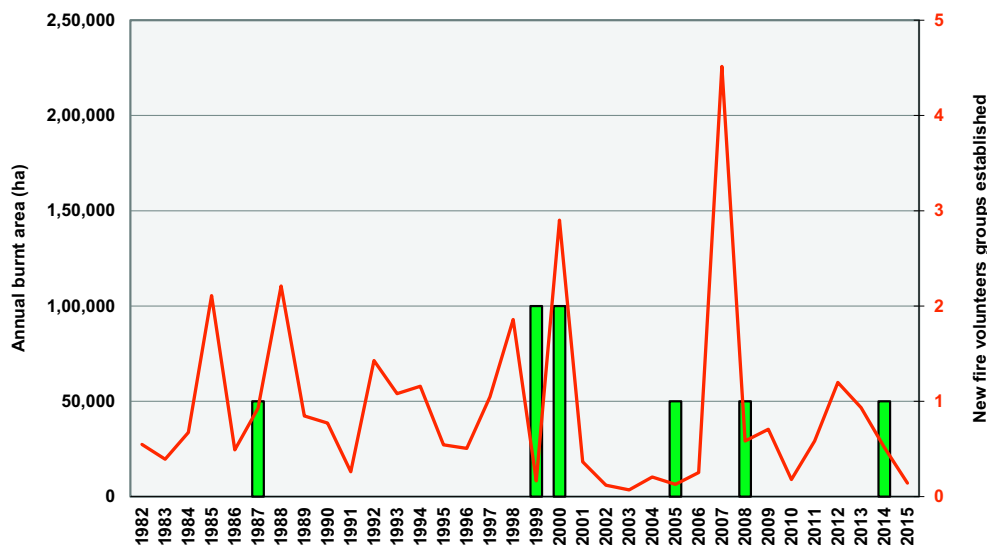


Fig. 3. Evolution of the establishment of fire volunteer groups in Greece according to available information and annual burnt area. Source: Greek surveys, and EFFIS (2017).

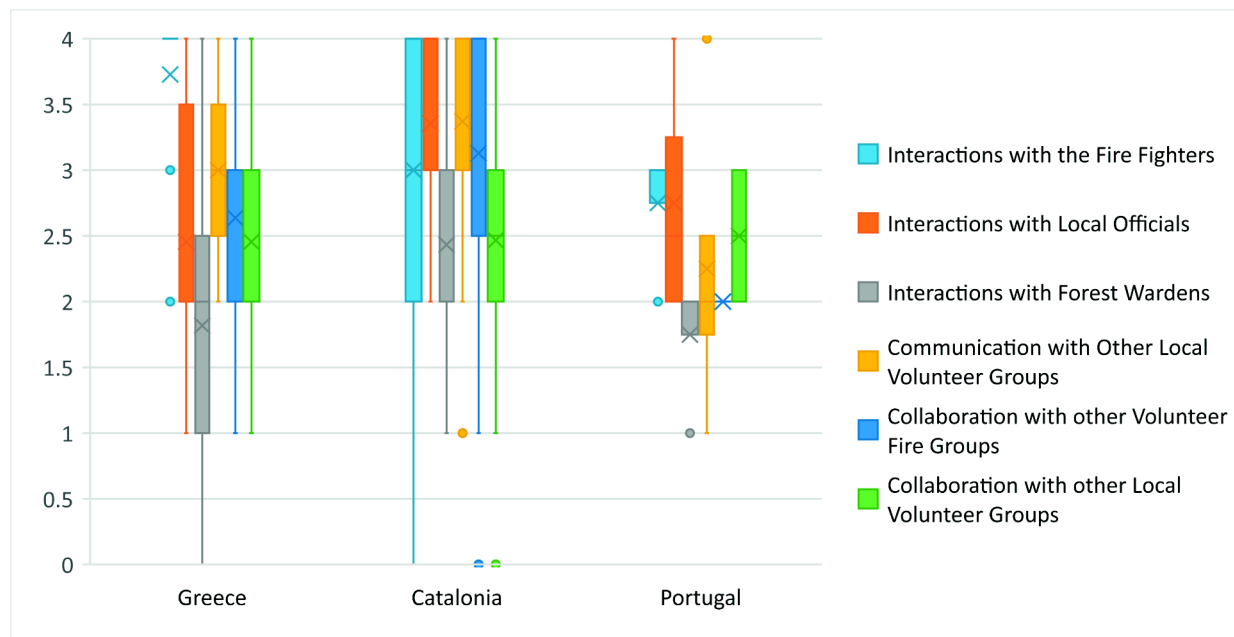


Fig. 4. Frequency of interactions as indicator of the strength of the groups' Structural SC at the regional level (Greece, Catalonia region in Spain, and Portugal). 4 = very often, whereas 0 = never. $N = 45$.

3.3. Social capital of the fire volunteers affect their array of activities

The main goal of this research is to show whether the strength of the groups' SC impacts their portfolio of fire related activities.

The regression model run shows (Table 3) how the number of activities implemented by the fire volunteer groups is significantly and positively² affected by both structural ($p < .001$) and relational SC ($p = .035$). Moreover the model records a minor effect of the total number of members involved in the group, which contributes significantly to the final number of activities delivered ($p = .029$). No statistically significant evidence has been found regarding the variety of

volunteer member profiles, or the forest area under the group scope.

Additionally, the correlation tests performed shows how the number of activities is also positively and significantly correlated to the diversity of the funding sources (Pearson coeff.: 0.58; t -test: 4.6; $p < .001$; $d.f.: 1,43$). It has been also observed that the antiquity of the group is positively related to the variety of activities (Pearson coeff.: 0.299; t -test: 9.7; $p = .051$; $d.f.: 42$).

3.4. Social capital slightly affects the perception on arsons

The results of the ordered logit model return a strong significant effect of the structural SC on the perception of arson reduction (Table 4; $p = .033$). On the contrary, relational SC is only close to its significance level ($p = .055$). This entails that, holding all other variables constant:

- An additional unit of Structural SC increases the likelihood of

² Note that given that the PCA factors are negative (Supplementary material 2), the negative estimated coefficients mean that the independent variable and the SC variables are positively related.

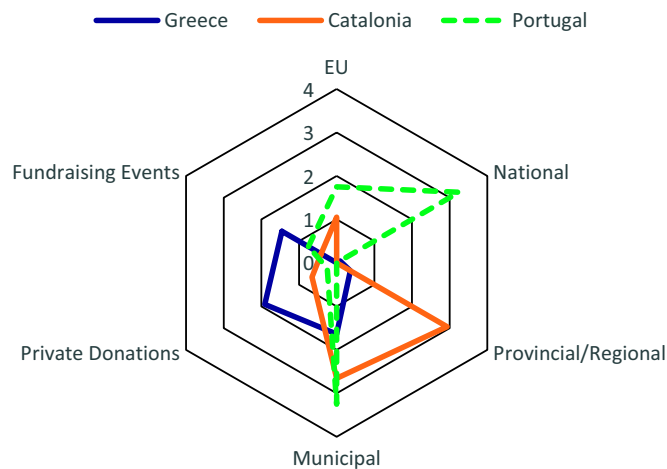


Fig. 5. Averaged frequency of funding sources used by wildfire volunteer groups. From 0 (never) to 5 (very often).

Table 3

Results of the OLS model for the factors affecting the volunteer groups' number of activities.

Independent variable ^a	Estimate	SE	t value	p(> t)
Intercept	9.776	1.142	8.562	< 0.001***
Structural SC	−1.259	0.257	−4.908	< 0.001***
Relational SC	−0.766	0.350	−2.191	0.035*
#members	0.009	0.004	2.275	0.029*
Members profile	−0.384	0.301	−1.275	0.211

R²: 0.49; d.f.: 5 and 35.

^a Stars indicate the significance levels: *** $p < .001$; ** $p = .01$; * $p = .05$.

Table 4

Results of the ordered Logit model on the factors affecting the group's perception of reduced arsons.

Explanatory variable	Estimate	t value	Odds ratio	95% CI	p(> t)
Structural SC	−0.407	−2.137	0.666	0.45;0.95	0.033*
Relational SC	−0.438	−1.922	0.645	0.40;0.99	0.055
#members	−0.005	−1.144	0.995	0.98;1.00	0.253
Cut1 ^a	−1.711	−3.143	–	–	0.002**
Cut2 ^a	0.904	1.814	–	–	0.070

Starting AIC: 85.3; final AIC: 83.7. Significance levels: *** $p < .001$; ** $p < .01$; * $p < .05$.

Cragg and Uhler's pseudo R²: 0.241.

^a Intercepts/cut points representing the 2 levels of the cumulative logit.

perceiving higher arson reduction by about 33%;

- An additional unit of Relational SC increases the likelihood of perceiving higher arson reduction by about 36%.

In terms of predicted probability (Table 5), we can observe how the

Table 5

Predicted probabilities of the different level of perceived arson reduction varying both relation and structural SC explanatory variables. Data derived from the ordered logit model. Only significant variables are shown.

		Relational Social Capital								
		HIGH	MED	LOW	HIGH	MED	LOW	HIGH	MED	LOW
Perceived arson reduction	LOW (= 0)	0.05	0.11	0.22	0.1	0.21	0.39	0.2	0.38	0.59
	MED (= 1)	0.36	0.51	0.57	0.5	0.57	0.51	0.57	0.52	0.36
	HIGH (= 2)	0.6	0.38	0.2	0.4	0.22	0.1	0.23	0.11	0.05
		HIGH	HIGH	HIGH	MED	MED	MED	LOW	LOW	LOW
		Structural Social Capital								

highest agreement level of perceived arson reduction is more likely to occur (0.60) when the group has high levels of both structural and relational SC. On the opposite side, the lowest level is more likely to occur when both type of SC are at their minimum (0.59). Lastly, a medium agreement level of perceived arson reduction is observed in a variety of combination (i.e. high relation SC and low structural SC; or low relational SC and high structural SC).

4. Discussion

This research has shed light on a seldom-studied citizen movement with a potential to have a significant impact on forest emergency management. Evidence about these grassroots initiatives has been found in three Mediterranean countries (Spain, Portugal and Greece). The knowledge gathered about these Mediterranean initiatives allow for some recommendations on advancing community adaptive capacity (Paveglio et al., 2009).

4.1. On the emergence, activities and funding

Replying to our first research question, the interviews, secondary sources and the surveys show a trend regarding the emergence: volunteer groups tend to be set up after catastrophic wildfire events. It could be interpreted that catastrophes act as trigger that mobilises societal willingness to prevent future problems, both at the implementation level to found local groups, and at the political level –in the Catalan and Portuguese cases- to configure the institutional framework (normative, incentives) for those voluntary initiatives. Wildfire experience could then trigger a reflection among the local community on the need to become further resilient to contingencies, where a possible action is the voluntary association to prepare and/or protect their community assets. This is aligned with Carroll et al. (2005) finding of newly established local assistance groups after wildfires. The institutional setting and its evolution seems to affect directly the consolidation of these grassroots initiatives, in terms of rights to intervene in fire events and their interaction with official bodies, as well as in terms of funding to conduct the activities. Hence, it is difficult to disclose a possible cause-effect relation: whether the collective action motivated the institutional framework, or the institutional framework smoothed and motivated locals to set up such groups. This because in some cases the community awareness is only immediate and wanes after a while, thus making stronger catastrophe-related new network relations among locals not necessarily leading to preparedness or mitigation activities (Jakes and Langer, 2012). Hence, an institutionalised framework for volunteer groups can help channelling their type of activities (not only suppression-focused –seen in the Portuguese case) and incentivise those beyond the initial post-fire years –seen in the regular subsidies of the Catalan case.

Referring to our second question, the main stakeholders to coordinate with are the professional firefighters (for suppression), the forest wardens (for prevention and preparedness) and the municipality agents. Catalonia shows the largest interaction with other groups. This figure is in line with the Californian Fire Safe Councils, where 64%

collaborate with other organisations (Everett and Fuller, 2011). While the last (relation with local officials) seems to be rather fluid, the reported interactions with firefighters and especially forest wardens is less frequent. This can be attributed to the nearest linkages with locals, however a smoother relation with the other official bodies could be beneficial for all actors.

In terms of portfolio of activities, the largest difference across case studies is that, in Greece, forest fire suppression makes up a much larger percentage of the activities compared to Catalonia and Portugal. Almost 50% percent of the activities conducted are in suppression in Greece, whereas only 18% of groups' activities focused on preparedness. Awareness campaigns also seem to make up a crucial portion of the group activities in comparison to the other case studies (Greece: 30.9%; Catalonia: 25.6%; Portugal: 23.7%).

The stark contrast comes in the form of public funding. In Catalonia and Portugal, more than 80% of their funding comes from public sources, while that source represents less than 50% of funding in Greece, with private donations and fund-raising events having much more importance than in the others. One Greek group stated that while they received funding from the national government, it was very seldom. Hence, the Catalan and Portuguese systems would rather assimilate to the US Fire Safe Councils (Everett and Fuller, 2011).

4.2. On the effects of social capital

Some authors propose that the wise integration of human activity “firescapes” is through building Fire-adapted Communities, i.e. landscape areas where the population undertakes proactive measures to live with wildfires (Smith et al., 2016). The surveyed fire volunteer groups display that their SC, especially in its structural dimension, correlates to the variety of activities related to wildfire risk management in their localities. This result assimilates Agrawal and Monroe (2006) findings in three Florida communities, where people perceiving greater SC are more likely to implement fire defence measures around their homes. It could therefore be derived that fostering local interactions among volunteer groups and other official bodies could facilitate the proactivity of local communities facing wildfire risk. In this sense, Agrawal and Monroe (2006) found that talking and giving credit to community members and leaders influence the dynamics for fire preparedness. Smith et al. (2016) also state that achieving fire-adapted communities requires making the general public partners in initiatives to manage wildfire risk.

Our findings also illustrate that SC relates to the perception of reduction of arsons (research question 4). Contrary to our expectations, trust statistical significance is low. This finding could be interpreted that local community members do not substantially change their confidence in other stakeholders as they may know them well before joining/establishing the volunteers' group, and instead the recurrent interactions through the volunteer group could indeed slightly decrease the chances for arsons. Such interpretation would contradict previous scholars' evidence that trust between communities and public agencies was building and strengthening as a result of community preparedness activities (Jakes et al., 2007).

In line with the Social Innovation cycle (Murray et al., 2010), the analysed initiatives could be in the step of scaling out and spreading. Indeed, in Portugal the ZIFs are managed often at a scale over the single ZIF, and in Catalonia many ADFs join in county-level federations. Those umbrella organisations facilitate their replication in new municipalities. Yet, an umbrella organization would be missing for the Greek case, which would facilitate the effective coordination and development of the groups' actions.

Further research involving more observations could shed light on possible categories within the fire volunteer groups depending on a rural-urban gradient or type of WUI community (Carroll and Paveglio, 2016). In addition, the relation and differences between these groups and volunteer fire fighters could be explored, which seem to exist in

each of the analysed areas, but their roles within the wildfire governance system remain unclear.

5. Conclusions

Wildfire is the main threat in Mediterranean forest ecosystems, with prospects of increasing in virulence, along with climate change. Human communities interacting with such ecosystems need some tools to adapt their settlements to fire disturbances. Usually, the welfare state service of fire fighters covers the suppression phase of the fire cycle. Yet, prevention and preparedness, as well as first intervention fall often far from fire fighters' tasks or possibilities. Hence, coping with such challenge, some rural communities have proactively established volunteer groups to tackle fire emergencies and regular preventive actions (e.g. awareness raising, preparation of infrastructures). Yet, the limited presence of those groups in the Mediterranean territory makes them a social innovation with perspectives of spreading, as their experiences become constructive.

This study has analysed the patterns of cooperation of fire volunteer groups in Greece, Portugal and Catalonia. The results show that their emergence often responds to a catastrophic fire season and their consolidation largely goes hand-in-hand with their institutionalisation and public support. Their main activities relate to fire preparedness and suppression, with some differences across the studied cases. Often these grassroots initiatives also implement preventive and awareness actions within the municipality. The wildfire-related actions these communities perform permit experimenting ad-hoc strategies to tackle wildfires, which need to be coordinated with the professional extinction bodies. Such experiences would increase the adaptation of those communities to fire. We find that stronger internal or external community bonds as well as their levels of trust, affect the variety of activities the groups conduct, and their perception about arsonism in the area. Derived from this, we put forward the need to establish and/or increase the communication and collaboration flows between official bodies and local citizens, as well as to provide legal platforms for channelling such initiatives. Acknowledging the limitations of our exploratory findings, these analyses highlight the relevance of SC as crucial element to improve rural welfare. Fire adaptation becomes, then, “a journey” and not a checklist (www.fireadapted.org), where rural communities can exercise their agency to increase their resilience and shape their own fate (Carroll and Paveglio, 2016:2).

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.forpol.2019.03.007>.

References

Agrawal, S., Monroe, M., 2006. Using and improving social capital to increase community

- preparedness for wildfire. In: McCaffrey, S.M. (Ed.), *The Public and Wildland Fire Management*. U.S. Department of Agriculture, Forest Service, Newtown Square, PA, pp. 163–167.
- Andriani, L., Christoforou, A., 2016. Social capital: a roadmap of theoretical and empirical contributions and limitations. *J. Econ. Issues* 50, 4–22. <https://doi.org/10.1080/00213624.2016.1147296>.
- Beighley, M., Hyde, A.C., 2009. Systemic risk and Portugal's forest fire defense strategy. An assessment of wildfire management and response capability.
- Bihari, M., Ryan, R., 2012. Influence of social capital on community preparedness for wildfires. *Landsc. Urban Plan.* 106, 253–261. <https://doi.org/10.1016/j.landurbplan.2012.03.011>.
- Biro, Y., 2009. *Living with Wildfires: What Science Can Tell Us*. European Forest Institute.
- Bodin, Ö., Crona, B.I., 2009. The role of social networks in natural resource governance: what relational patterns make a difference? *Glob. Environ. Chang.* 19, 366–374. <https://doi.org/10.1016/j.gloenvcha.2009.05.002>.
- Bombers, 2017. Gràfica de la paradoxa d'extinció.
- Canadas, M.J., Novais, A., Marques, M., 2016. Wildfires, forest management and landowners' collective action: a comparative approach at the local level. *Land Use Policy* 56, 179–188. <https://doi.org/10.1016/j.landusepol.2016.04.035>.
- Carroll, M., Paveglio, T., 2016. Using community archetypes to better understand differential community adaptation to wildfire risk. *Phil. Trans. R. Soc. B.* 371, 20150344. <https://doi.org/10.1098/rstb.2015.0344>.
- Carroll, M.S., Cohn, P.J., Seesholtz, D.N., Higgins, L.L., 2005. Fire as a galvanizing and fragmenting influence on communities: the case of the Rodeo–Chediski fire. *Soc. Nat. Resour.* 18, 301–320. <https://doi.org/10.1080/08941920590915224>.
- Collins, R.D., 2007. *Forest fire management in Portugal: Developing system insights through models of social and physical dynamics*. Massachusetts Institute of Technology.
- Davenport, M.A., Leahy, J.E., Anderson, D.H., Jakes, P.J., 2007. Building trust in natural resource management within local communities: a case study of the Midewin national tallgrass prairie. *Environ. Manag.* 39, 353–368. <https://doi.org/10.1007/s00267-006-0016-1>.
- EFFIS, 2017. *European Fire Database - Total burnt areas 1980–2015*.
- Everett, Y., Fuller, M., 2011. Fire safe councils in the interface. *Soc. Nat. Resour.* 24, 319–333. <https://doi.org/10.1080/08941920903313835>.
- Fairbrother, P., Mees, B., Phillips, R., Stratford, J., Toh, K., 2013. Creating “community”? Preparing for bushfire in rural Victoria. *Rural. Sociol.* 78, 186–209. <https://doi.org/10.1111/ruso.12006>.
- Fischer, A.P., Jasny, L., 2017. Capacity to adapt to environmental change: evidence from a network of organizations concerned with increasing wildfire risk. *Ecol. Soc.* 22, 23.
- Frandsen, M., Paton, D., Sakariassen, K., 2011. Fostering community bushfire preparedness through engagement and empowerment. *Aust. J. Emerg. Manag.* 26, 23–30.
- Gan, J., Jarrett, A., Gaither, C.J., 2015. Landowner response to wildfire risk: adaptation, mitigation or doing nothing. *J. Environ. Manag.* 159, 186–191. <https://doi.org/10.1016/j.jenvman.2015.06.014>.
- González-Hidalgo, M., Otero, I., Kallis, G., 2014. Seeing beyond the smoke: the political ecology of fire in Horta de Sant Joan (Catalonia). *Environ. Plan. A* 46, 1014–1031. <https://doi.org/10.1068/a45600>.
- Granovetter, M.S., 1973. The strength of weak ties. *Am. J. Sociol.* 78, 1360–1380.
- Greiving, S., Sapountzaki, K., Ferri, F., Grifoni, P., Firus, K., Xanthopoulos, G., Technologies, R., 2012. Linking the Actors and Policies throughout the Disaster Management Cycle by “Agreement on Objectives” – A New Output-Oriented Management Approach. pp. 1085–1107. <https://doi.org/10.5194/nhess-12-1085-2012>.
- Hesseln, H., 2018. Wildland fire prevention: a review. *Curr. For. Reports.* 4 (4), 178–190. <https://doi.org/10.1007/s40725-018-0083-6>.
- ICNF, I.P., 2017. Zonas de Intervenção Florestal constituídas on 09.08.2017.
- Jakes, P.J., Langer, E.R.L., 2012. The adaptive capacity of New Zealand communities to wildfire. *Int. J. Wildl. Fire* 764–772.
- Jakes, P., Kruger, L., Monroe, M., Nelson, K.C., Sturtevant, V., 2007. Improving wildfire preparedness: lessons from communities across the U. S. *Hum. Ecol. Rev.* 14, 188–197.
- Kurtulmuslu, M., Yazici, E., 2000. Management of forest fires through the involvement of local communities in Turkey. In: *Community-Based Fire Management: Case Studies from China, The Gambia, Honduras, India, the Lao People's Democratic Republic and Turkey, Bangkok, Thailand*, pp. 122–137.
- Macdougall, C., Gibbs, L., Clark, R., 2014. Community-based preparedness programmes and the 2009 Australian bushfires: policy implications derived from applying theory. *Disasters* 38, 249–266.
- McCaffrey, S., 2004. Thinking of wildfire as a natural hazard. *Soc. Nat. Resour.* 509–516.
- McCaffrey, S., 2015. Community wildfire preparedness: a global state-of-the-knowledge summary of social science research. *Curr. For. Reports* 81–90. <https://doi.org/10.1007/s40725-015-0015-7>.
- McCaffrey, S., Toman, E., Stidham, M., Shindler, B., 2012. Social science research related to wildfire management: an overview of recent findings and future research needs. *Int. J. Wildl. Fire* 22, 15–24.
- McGee, T.K., 2011. Public engagement in neighbourhood level wildfire mitigation and preparedness: case studies from Canada, the US and Australia. *J. Environ. Manag.* <https://doi.org/10.1016/j.jenvman.2011.05.017>.
- McLennan, J., Birch, A., 2005. A potential crisis in wildfire emergency response capability? Australia's volunteer firefighters. *Environ. Hazards* 6, 101–107. <https://doi.org/10.1016/j.hazards.2005.10.003>.
- Moritz, M.A., Batllori, E., Bradstock, R.A., Gill, A.M., Handmer, J., Hessburg, P.F., Leonard, J., McCaffrey, S., Odion, D.C., Schoennagel, T., Syphard, A.D., 2014. Learning to coexist with wildfire. *Nature* 515, 58–66. <https://doi.org/10.1038/nature13946>.
- Murray, R., Caulier-Grice, J., Mulgan, G., 2010. *The Open Book of Social Innovation*.
- Nahapiet, J., Ghoshal, S., 1998. Social capital, intellectual capital and the organizational advantage. *Acad. Manag. Rev.* 23, 242–266.
- Oliveira, T., 2005. The Portuguese National Plan for Prevention and Protection of Forest Against Fires: The First Step. *Int. For. Fire News* 33, 30–34.
- Ostrom, V., Ostrom, E., 1977. Public goods and public choices. In: Savas, E.S. (Ed.), *Alternatives for Delivering Public Services: Towards Improved Performance*. Boulder. Westview Press, pp. 7–49.
- Pausas, J.G., Llovet, J., Rodrigo, A., Vallejo, R., 2008. Are wildfires a disaster in the Mediterranean basin? – a review. *Int. J. Wildl. Fire* 17, 713–723.
- Paveglio, T.B., Carroll, M.S., Williams, D.R., 2009. Understanding social complexity within the Wildland – Urban Interface: a new species of human habitation? *Environ. Manag.* 43, 1085–1095. <https://doi.org/10.1007/s00267-009-9282-z>.
- Peix, J., Ros, J.L., Vives, J.M., Garriga, J., 1993. Les agrupacions de defensa. *Quad. Agrar.* 16, 127–137.
- Polman, N., Slee, B., Kluvánková, T., Dijkshoorn, M., Nijnik, M., Gezick, V., 2017. Classification of Social Innovations for Marginalized Rural Areas.
- Pretty, J., 2003. Social capital and the collective management of resources. *Science*. <https://doi.org/10.1126/science.1090847>. (80–). 302, 1912–1914.
- Pretty, J., Ward, H., 2001. Social capital and the environment. *World Dev.* 29, 209–227. [https://doi.org/10.1016/S0305-750X\(00\)00098-X](https://doi.org/10.1016/S0305-750X(00)00098-X).
- Prior, T., Eriksen, C., 2013. Wildfire preparedness, community cohesion and social-ecological systems. *Glob. Environ. Chang.* 23, 1575–1586.
- Putnam, R.D., 2000. *Bowling Alone: the Collapse and Revival of American Community*. R Core Team, 2017. *R: a Language and Environment for Statistical Computing*.
- RStudio Team, 2017. *RStudio: Integrated Development for R*.
- Smith, A.M.S., Kolden, C.A., Paveglio, T.B., Cochrane, M.A., Bowman, D.M.J.S., Moritz, M.A., Kliskey, A.D., Alessa, L., Hudak, A.T., Hoffman, C.M., Lutz, J.A., 2016. The science of firescapes: achieving fire-resilient communities. *Bioscience* 66, 130–146. <https://doi.org/10.1093/biosci/biv182>.
- Solano, J.M., Fernández, J., Palahí, M., Pukkala, T., Prokofieva, I., 2007. Es rentable la gestión forestal en Cataluña? *Economistas* 116–124.
- Toman, E., Shindler, B., Brunson, M., 2006. Fire and fuel management communication strategies: citizen evaluations of agency outreach programs. *Soc. Nat. Resour.* 19, 321–336.
- Uslaner, E.M., 2001. *The Moral Foundations of Trust*. Cambridge University Press, Cambridge. <https://doi.org/10.1017/CBO9780511614934>.
- Valente, S., Coelho, C., Ribeiro, C., Soares, J., 2013. Forest intervention areas (ZIF): a new approach for non-industrial private forest management in Portugal. *Silva Lusit.* 21, 137–161.
- Vélez Muñoz, R., 2007. Experiences in Spain of community based fire management. In: *Wildfire 2007. 4th International Wildfire Conference*. Sevilla. pp. 13.
- Verkerk, P.J., Martínez de Arano, I., Palahí, M., 2018. The bio-economy as an opportunity to tackle wildfires in Mediterranean forest ecosystems. *For. Policy Econ.* 86, 1–3. <https://doi.org/10.1016/j.forpol.2017.10.016>.